Social Sustainability

Social Indicators for Sustainable Project and Technology Life Cycle Management in the Process Industry

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Abstract

Goal, Scope and Background. The importance of the social dimension of sustainable development increased significantly during the last decade of the twentieth century. Industry has subsequently experienced a shift in stakeholder pressures from environmental to social-related concerns, where new developments in the form of projects and technologies are undertaken. However, the measurement of social impacts and the calculation of suitable indicators are less well developed compared to environmental indicators in order to assess the potential liabilities associated with undertaken projects and technologies. The aim of this paper is to propose a Social Impact Indicator (SII) calculation procedure based on a previously introduced Life Cycle Impact Assessment (LCIA) calculation procedure for environmental Resource Impact Indicators (RIIs), and to demonstrate the practicability of the SII procedure in the context of the process industry in South Africa.

Methods. A framework of social sustainability criteria has been introduced for the South African process industry. The social sub-criteria of the framework are further analyzed, based on project and technology management expertise in the South African process industry, to determine whether the criteria should be addressed at project or technology management level or whether they should rather form part of an overall corporate governance policy for new projects and technologies. Furthermore, the proposed indicators for criteria that are considered appropriate for project or technology evaluation purposes are constrained by the type of information that is available, i.e. the calculation methodology relies on the availability of regional or national social information where the project will be implemented, as well as the availability of project- or technology-specific social information during the various phases of the project or technology development life cycle. Case studies in the process industry and statistical information for South Africa are subsequently used to establish information availability for the SII calculation procedure, demonstrate the SII method together with the RII method, and determine the practical use of the SII method.

Results and Conclusion. The case studies establish that social footprint information as well as project- and technology social data are not readily available in the South African process industry. Consequently, the number of mid-point categories that can be evaluated are minimal, which results in an impaired social picture when compared to the environmental dimension. It is concluded that a quantitative social impact assessment method cannot be applied for project and technology life cycle management purposes in industry at present.

Recommendation and Perspective. Following the outcomes of the case studies in the South African process industry, it is recommended that checklists and guidelines be used during project and technology life cycle management practices. Similar to the environmental dimension, it is envisaged that such checklists and guidelines would improve the availability of quantitative data in time, and would therefore make the SII procedure more practical in the future.

Keywords: Life Cycle Impact Assessment (LCIA); Life Cycle Management (LCM); process industry; Resource Impact Indicator (RII); Social Impact Indicator (SII); social sustainability

Introduction

The last decade of the twentieth century marked significant steps to draw the social dimension of sustainable development into the open [1]. The inclusion of social aspects in the sustainability debate and practice has nevertheless been marginal compared to the attention given to the other two dimensions, especially from a business perspective [1,2,3]. However, stakeholders are forcing companies to address the inclusion of social sustainability by shifting pressure from environmental to social related concerns [4,5]. The social dimension is commonly recognised as the 'weakest' pillar of sustainable development due to a lack of analytical and theoretical underpinnings [5] and it is believed that the state of development of indicators or measurements for social business sustainability parallels that of environmental performances about 20 years ago [6]. Nevertheless, there is a definite need for practical tools to introduce social sustainability into business evaluation processes [1,7,8].

This paper proposes a methodology to assess the social sustainability of projects and technologies in the process industry by calculating social impact indicators, and addresses the following two questions:

1) What social criteria must such an assessment methodology consider and measure?
2) How must these criteria be addressed and measured?

To address the first question, a framework of social business sustainability criteria is defined, which is relevant for operational initiatives in the process industry. Social sustainable development indicators are then introduced, demonstrated and discussed, based on the defined framework.

1 Social Sustainability Criteria Framework

1.1 Development of a framework for business management purposes in the process industry

The current indicator frameworks that are available to measure overall business sustainability do not effectively address social aspects of sustainability at operational level in the process industry, especially in developing countries such as South Africa [9]. The question arises what the exact scope of social sustainability should entail from a business management perspective. An analysis of current available frameworks, Social Impact Assessment (SIA) guidelines, Corporate Social Responsibility (CSR) literature and guidelines, and other international guidelines were undertaken (**Table 1**) [9].

The analysis showed that a comprehensive social sustainability framework should define appropriate criteria to address the company's impacts on the social systems in which it operates, as well as the company's relationship with its various stakeholders. A sustainable development framework for operational initiatives was subsequently developed and proposed, the social dimension of which is shown in **Fig. 1**. **Table 2** provides the definitions of the criteria at the different levels of the framework, which are described in detail elsewhere [9].

Table 1: Analysis of the social criteria addressed by current frameworks and guidelines [9]

Name and type of literature	Criteria								
	Society								
	Health	Education	Environment	Housing / Living conditions	Security / Crime	Facilities & Services	Population characteristics	Community characteristics	Economic welfare / Employment
Indicator frameworks									
United Nations[1]	×	×		×	×	×	×		×
Global Reporting Intitiative[2]	×			×	×	×	×	×	
IchemE Sustainability Metrics[3]								×	×
Wuppertal Indicators[4]	×	×	×	×		×		×	
European Conceptual Framework for Social Ind.[5]	×	×	×	×	×	×	×	×	×
SIA literature									
Interorganizational Committee on Guidelines and Principles[6]	×		×	×	×	×	×	×	×
Socioeconomic impacts for Energy Efficiency Project for Climate Change Mitigation[7]	×	×		×	×		×	×	×
South Sydney Council SIA checklist[8]	×	×		×	×	×	×	×	×
SIA categories for development projects in South Africa[9]	×	×		×	×	×	×	×	×
South African social criteria for CDM project evaluation[10]						×			×
Classification of social impacts according to Vanclay[11]	×	×	×	×	×	×	×		×
Classification of social impacts according to Juslén[11]	×		×	×	×	×	×	×	
Classification of social impacts according to Gramling and Freudenburg[11]	×	×	×	×	×	×	×	×	×
SIA Series' Guide to Social Assessment[12]	×					×	×	×	×
Government actions									
European Greenpaper on CSR[13]	×	×		×	×	×	×	×	×
Pressures from international financing organisations									
World Bank's Social Analysis Sourcebook[14]							×	×	
SRI Indexes									
Dow Jones Sustainability Index[15]									×
FTSE 4 GOOD[16]									×
JSE SRI Index[17]									×
Dominini 400 Index[18]		×	×	×				×	×
International standards and guidelines									
Global Compact[19]									
Global Sullivan Principles[20]									
Caux Round Table[21]									
OECD Guidelines[22]									
SA 8000[23]									
AA 1000[24]									
Investors in People[25]									
Ethical Trading Initiative[26]									
CSR standards									
Ethos Indicators[27]			×			×		×	×
Standards of CSR[28]									×
Danish Social Index[29]									×

Table 1: Analysis of the social criteria addressed by current frameworks and guidelines [9] (*cont'd*)

Name and type of literature	Criteria								
	Society	Society and company (interlinkage)			Company internal				
	Community cohesion	Product responsibility	Community involvement of company	Stakeholder participation / Engagement	Training, education of staff	Equity	Fair labour practices	Human rights	Employee health and safety
Indicator frameworks									
United Nations[1]						×			
Global Reporting Intitiative[2]	×	×	×	×	×	×	×	×	×
IchemE Sustainability Metrics[3]				×		×	×		×
Wuppertal Indicators[4]						×			
European Conceptual Framework for Social Ind.[5]	×								
SIA literature									
Interorganizational Committee on Guidelines and Principles[6]	×			×		×			
Socioeconomic impacts for Energy Efficiency Project for Climate Change Mitigation[7]	×			×	×	×	×		
South Sydney Council SIA checklist[8]	×				×				
SIA categories for development projects in South Africa[9]	×			×	×	×			
South African social criteria for CDM project evaluation[10]				×	×	×			
Classification of social impacts according to Vanclay[11]	×					×	×		
Classification of social impacts according to Juslén[11]	×								
Classification of social impacts according to Gramling and Freudenburg[11]	×					×			
SIA Series' Guide to Social Assessment[12]	×								×
Government actions									
European Greenpaper on CSR[13]	×		×			×	×	×	×
Pressures from international financing organisations									
World Bank's Social Analysis Sourcebook[14]	×		×	×		×		×	
SRI Indexes									
Dow Jones Sustainability Index[15]		×	×	×	×	×	×	×	×
FTSE 4 GOOD[16]			×	×	×	×	×	×	×
JSE SRI Index[17]			×	×	×	×	×	×	×
Dominini 400 Index[18]		×	×		×	×	×	×	×
International standards and guidelines									
Global Compact[19]			×			×	×	×	×
Global Sullivan Principles[20]			×	×	×	×	×	×	×
Caux Round Table[21]			×	×	×	×	×	×	×
OECD Guidelines[22]			×	×	×		×	×	×
SA 8000[23]	×				×	×	×	×	×
AA 1000[24]	×		×	×		×	×	×	×
Investors in People[25]	×				×	×	×	×	×
Ethical Trading Initiative[26]	×					×	×	×	×
CSR standards									
Ethos Indicators[27]		×	×	×	×		×		×
Standards of CSR[28]			×	×	×	×	×	×	×
Danish Social Index[29]			×	×	×	×	×	×	×

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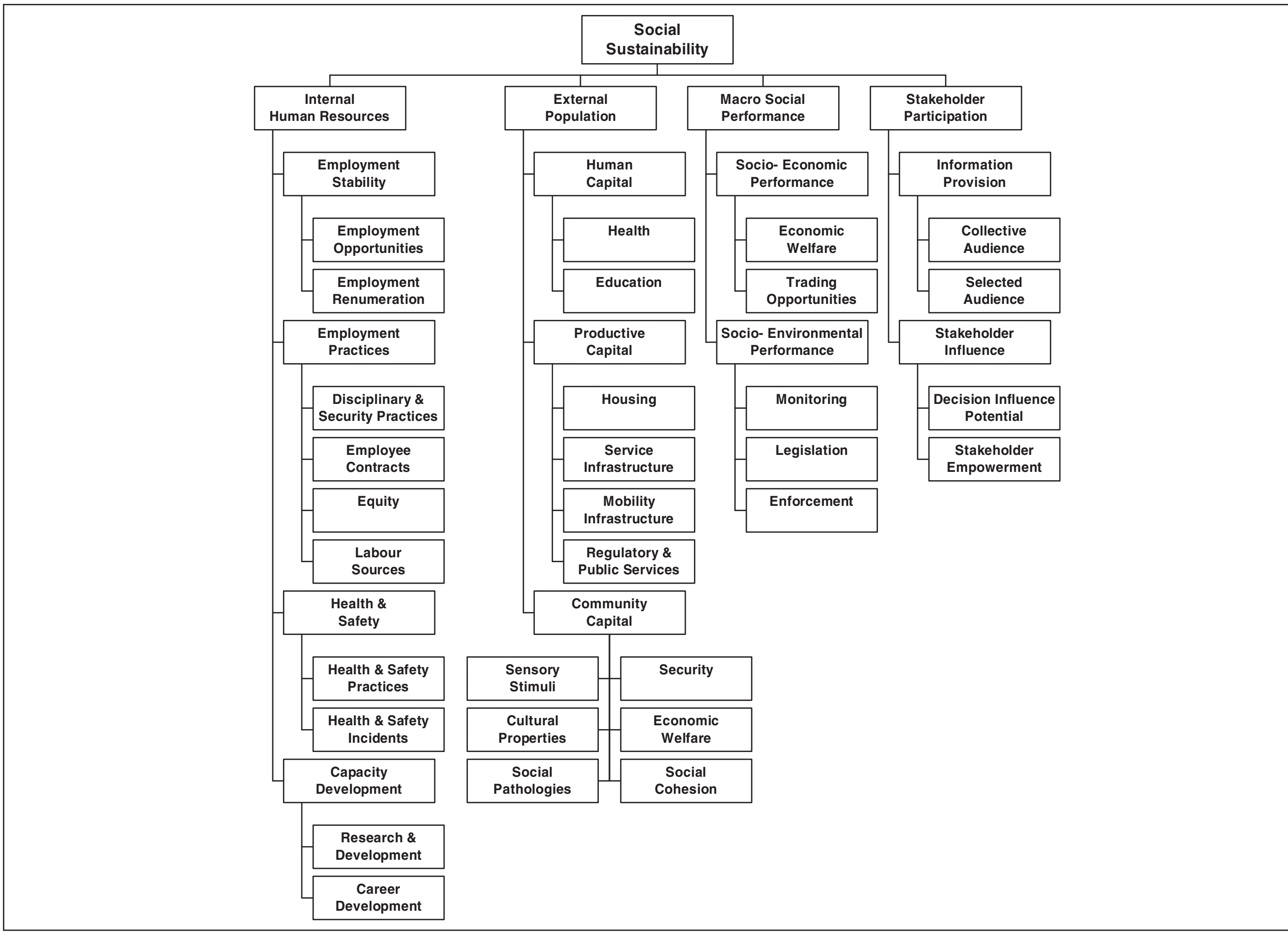

Fig. 1: Framework to assess the social sustainability of engineering projects and technologies [9]

Table 2: Definitions of Social Criteria [9]

Internal Human Resources	**Internal Human Resources focuses on the social responsibility of the company towards its workforce and includes all aspects of employment.**
Employment Stability	The criterion addresses a business initiative's impact on work opportunities within the company, the stability thereof as well as evaluating the fairness of compensation.
Employment Practices	Disciplinary and secrecy practices as well as employee contracts are addressed under this criterion. These are evaluated to ensure that it complies with the laws of the country, international human rights declarations as well as other human rights and fair employment practice standards.
Health & Safety	The criterion focuses on the health and safety of the workforce and evaluates preventive measures as well as the occurrence and handling of health and/or safety incidents.
Capacity Development	The criterion addresses two different, aspects namely research and development, and career development.
External Population	**External Population focuses on the external impacts of the company's operational initiatives on a society, e.g. impacts on the availability of services, community cohesion, economic welfare, etc.**
Human Capital	Human Capital refers to an individual's ability to work in order to generate an income and encompasses aspects such as health, psychological wellbeing, education, training and skills levels. The criterion addresses Health and Education separately.
Productive Capital	Productive capital entails the assets and infrastructure an individual needs in order to maintain a productive life. The criterion measures the strain placed on these assets and infrastructure availability by the business initiative.
Community Capital	This criterion takes into account the effect of an operational initiative on the social and institutional relationships and networks of trust, reciprocity and support as well as the typical characteristics of the community.
Macro Social Performance	**Macro Social Performance focuses on the contribution of an organisation to the environmental and financial performance of a region or nation, e.g. contribution to exports.**
Socio-Economic Performance	This criterion addresses the external economic impact of the company's business initiatives. Economic welfare (contribution to GDP, taxes, etc.) as well as trading opportunities (contribution to foreign currency savings, etc.) are addressed separately.
Socio-Environmental Performance	This criterion considers the contributions of an operational initiative to the improvement of the environment for society on a community, regional and national level. The extension of the environmental monitoring abilities of society, as well as the enhancement of legislation and the enforcement thereof, are included in this criterion.
Stakeholder Participation	**Stakeholder Participation focuses on the relationships between the company and ALL its stakeholders (internally and externally) by assessing the standard of information sharing and the degree of stakeholder influence on decision-making.**
Information Provisioning	The quantity and quality of information shared with stakeholders are measured. Information can either be shared openly with all stakeholders (Collective Audience) or shared with targeted, specific groups of stakeholders (Selected Audience).
Stakeholder Influence	The degree to which the company actually listens to the stakeholders' opinion should also be evaluated. Two separate sub-criteria are included: Decision Influence Potential and Stakeholder Empowerment.

1.2 Verification and validation of the completeness and relevance of the social criteria of the framework

The social sustainability framework was verified by means of case studies testing the completeness and relevance of its criteria. Since the aim of the framework is to assess the social sustainability of projects and technologies in the process industry, ten case studies were chosen that represent the three phases of the asset, or technology, life cycle with the greatest potential to cause social impacts, i.e. the Construction Phase, the Operation Phase, and the Decommissioning Phase. The rationale for focussing on the three asset life cycle phases, as well as the interaction between asset and project life cycles, can be found in literature [10]. The case studies aimed to describe the significant social impacts that may occur during the life cycle phases in relation to the proposed framework, and to identify any social impacts that cannot be classified into the framework [11]:

- The construction of three process industry facilities: an incinerator, a mine, and a gas pipeline.
- The operation of four chemical manufacturing facilities, one in Germany, one in the USA, and two in different provinces in South Africa.
- The decommissioning of three process industry facilities: a cyanide manufacturing plant, an acrylic fibre manufacturing plant, and a mine.

Project related documentation, pertaining to each of the case studies, was evaluated and personal interviews were held with project responsible individuals [11]. It must be noted that in case study research it is not easy to generalise results, since statistical analysis cannot necessarily be applied. Cases are not sampling units and cannot be treated as such.

The conclusion was reached that no social aspect of the ten projects could be found that could not be classified into the criteria framework. In addition, all of the social criteria did not manifest in each asset life cycle phase. However, there may be social aspects that did not manifest in either the case studies or the framework. Nevertheless, the basis on which the individual case studies were chosen makes these cases adequately representative of the current social environment in which construction, operation, and decommissioning occurs in the process industry. It is subsequently concluded that the framework is complete enough to be used as an initial basis to develop a social assessment methodology, which can incorporate social sustainability into project and technology management practices.

The social sustainability framework was further validated by means of a Delphi Technique survey [12]. The survey focused on the relevance of the proposed social criteria for the evaluation of projects or technologies and attempted to answer whether the project team, a functional unit within an organisation, or an organisation's corporate governance framework should address the different social aspects. A total of 23 project management experts in a process industry company in South Africa participated in the survey, which established the suitability of the social criteria, as well as the relevance of the criteria in terms of sustainable business practices. The outcomes of the survey support the conclusion reached by the case studies, but also suggest, according to the opinion of project management experts, that all the criteria are not relevant to project and technology management, but should rather manifest as part of corporate policy (**Table 3**) [11].

Table 3: Delphi Technique survey results [11]

Criterion	The criterion should be addressed by…		
	Project	Business Strategy	Functional Department
Employment Opportunities	x	x	x
Employment Remuneration		x	x
Disciplinary & Security Practices			x
Employee Contracts		x	x
Equity & Diversity		x	x
Labour Sources	x	x	x
Health & Safety Practices	x	x	x
Health & Safety Incidents	x	x	x
Research Development	x	x	
Career Development			x
Health	x	x	
Education	x	x	x
Housing	x	x	
Service Infrastructure	x	x	
Mobility Infrastructure	x	x	
Regulatory & Public Services/ Institutional Services		x	
Sensory Stimuli	x	x	x
Security	x	x	
Cultural Properties	x	x	
Economic Welfare	x	x	
Social Pathologies	x	x	
Social Cohesion	x	x	
Economic Welfare		x	
Trading Opportunities		x	
Monitoring			x
Legislation	x	x	
Enforcement	x	x	x
Information Provisioning	x	x	
Stakeholder Influence		x	

2 Social Impact Indicator (SII) Calculation Procedure

The main focus of this paper is the development and testing of a quantitative social sustainable development indicator calculation method. A life cycle impact assessment (LCIA) approach has been proposed before for the evaluation of the social impacts of life cycle systems from compiled LCIs [13,14]. An introduced LCIA methodology developed specifically for the South African context, termed the Resource Impact Indicator (RII) approach [15], is thereby used as basis for the development of social indicators. The environmental RII approach considers the current and target ambient state or ecological footprint through a conventional distance-to-target normalisation and weighting calculation procedure [15].

A similar calculation procedure is proposed for Social Impact Indicators (SII), using the four main social criteria (shown in Fig. 1) as Areas of Protection (AoP). Three of these criteria represent the main groups of social resources on which the company can have an impact, while the fourth criterion represents all relationships between the company and stakeholders. The general SII calculation procedure is described through **Eq. 1**.

$$SII_G = \sum_C \sum_X Q_X \cdot C_C \cdot N_C \cdot S_C \tag{1}$$

Where:

SII_G = Social Impact Indicator calculated for a main social resource group through the summation of all impact pathways of all categorised social interventions of an evaluated life cycle system.

Q_X = Quantifiable social intervention (X) of a life cycle system in a midpoint impact category C, i.e. project or technology specific information with regards to social impacts.

C_C = Characterisation factor for an impact category (of intervention X) within the pathway. As a first approximation no characterisation factors are assumed and social LCI constituents are considered separately.

N_C = Normalisation factor for the impact category based on the social objectives in the region of assessment, i.e. the inverse of the target state of the impact category. The information is obtained from social footprint data in the region of the assessment.

And,

$S_C = \frac{C_S}{T_S} =$ Significance (or relative importance) of the impact category in a social group based on the distance-to-target method, i.e. current social state divided by the target social state (see section 1.2).

To develop the calculation method, the same case studies used for the verification of the social criteria (see section 1.2) were used to compile a list of possible social interventions, i.e. a social Life Cycle Inventory (LCI) of assessed operational initiatives in the process industry. However, the RII method makes use of mid-point categories. To define midpoint categories, the list of social interventions was mapped against the social criteria at various levels within the proposed social sustainability framework. A causal relationship diagram was consequently established for each of the four main social criteria, which define the midpoint categories. These causal diagrams are shown in the Appendix [16].

Three measurement methods are proposed to express the defined midpoint categories in equivalence units (**Table 4**) [17]:

- Established risk assessment approaches, which require a subjective evaluation of the probability of occurrence, the projected frequency of the occurrence, and the potential intensity thereof;

Table 4: Midpoint categories and evaluation methods [17]

Social Impact Indicators (SIIs)	Midpoint category	Measurement methods to establish equivalence units
Internal Human Resources	Permanent internal employment positions	Quantitative
	Internal Health and Safety situation	Risk
	Knowledge level / Career development	Quantitative
	Internal Research and Development capacity	Quantitative
External Population	Comfort level / Nuisances	Risk
	Perceived aesthetics	Qualitative
	Local employment	Quantitative
	Local population migration	Qualitative
	Access to health facilities	Quantitative
	Access to education	Quantitative
	Availability of acceptable housing	Quantitative
	Availability of water services	Quantitative
	Availability of energy services	Quantitative
	Availability of waste services	Quantitative
	Pressure on public transport services	Quantitative
	Pressure on the transport network / People and goods movement	Quantitative
	Access to regulatory and public services	Quantitative
Stakeholder Participation	Change in relationships with stakeholders	Qualitative
Macro-Social Performance	External value of purchases / supply chain value/Nature of Purchases	Quantitative
	Migration of clients / Changes in the product value chain/Nature of Sales	Qualitative/Quantitative
	Improvement of socio-environmental services	Quantitative

Table 5: Proposed Midpoint Categories for the four main social criteria together with proposed units of equivalence

Social AoP	Midpoint Category	Units of equivalence	Intervention Information, i.e. project or technology information	Social Footprint Information needed
Internal Human Resources	Permanent Internal Employment Positions	Number of employment opportunities equivalent to a specific position	Number and type of employment opportunities created or destroyed	Employment by type, i.e. position and full-time/part-time, for municipality
	Possible Health and Safety Incidents	Fatality or Disability Injury Rate	Risk of health and safety incidents with prediction of number based on similar previous undertakings	Industry fatal accident or disability injury rate
	Internal Research & Development Capacity	Cost spend on R&D capacity	Investment by project in R&D as part of project budget	Municipality budget on R&D or industry budget
External Population	Comfort Level/Nuisances	Risk of uncomfort/ Kilo tons of pollutants emitted per annum	Predicted emissions that can smell or risk of emissions	Emissions and noise level of municipality as well as acceptable levels by standards, e.g. SABS standards
			Predicted noise levels or risk of noise	
	Aesthetics	Level of perceived acceptability	Risk of structure and location having a negative impact on aesthetics of community	Perceived level of aesthetic acceptability by community
	Local Employment	Fraction of employable community hours	Number of permanent job type equivalents	Employment by type for community or municipality
			Calculation: permanent positions multiplied by conversion factor	
	Local Population Migration	Level of short-term demographic changes	Predicted change in local population	Demographic profile of community or municipal area
	Access to health facilities	People per qualified doctor	Predicted increase or decrease in ratio, focus only on public health sector	National ratio of people per qualified doctor or international ratio
	Access to Education	Literate adults	Predicted impact on the number of literate adults	Literate adults in municipality area or region
	Availability of acceptable houses	Zoned residential area per capita	The predicted need for houses which must be build multiplied by the average size	Size of municipality area
	Availability of water services	Water of drinking quality per capita	Quantity of water used or supplied	Water of drinking quality used by municipality
	Availability of energy services	kWh of electricity per capita	Quantity of electricity used or supplied	Electricity usage by municipality
	Availability of waste services	Capita per G:h landfill site	Quantity of waste generated and/or quantity of waste removed from municipal area	Landfill sites (type and size) used by municipality
	Pressure on public transport services	Seat kilometres per capita	Number of additional public transport seats required	Public Transport seats available in municipal area
	Pressure on transport network/ People and goods movement	Ton kilometres per capita	Tons of good transported on roads and or kilometre of road infrastructure provided	Ton kilometres per capita (in region or nationally)
Macro Social Performance	External value of purchases	Fraction of purchased locally-manufactures goods	Percentage of turnover or expenses spend locally	Gross Domestic Product (GDP) per region and/or per industry.
	Improvement of Socio-Environmental Services	Cost spent on SE services per capita	Monetary amount spend on services, resources or information that will improve macro environmental performance	Monetary amount spent on Environmental Services by the region, i.e. provincial government or municipal council
Stakeholder Participation	Change in relationships with stakeholders	Level of stakeholder trust	Predicted Percentage improvement or deterioration in perceived stakeholder trust	Perceived stakeholder trust based on community questionnaires or surveys

- Quantitative evaluation approaches, including, but not limited to, costs and direct measurements in society; and
- Qualitative evaluation approaches, which require appropriate subjective scales and associated guidelines, and have been proposed for the industrial ecology and streamlined LCA disciplines (see section 1.2).

The defined midpoint categories, which, from the validation survey (see section 1.2), are considered appropriate at project or technology management level, together with proposed units of equivalence for evaluation purposes are shown in **Table 5**. The units of equivalence were determined from the characteristics of the social interventions identified from the ten case studies. The definitions of the midpoint categories make it evident that the normalisation and significance steps will be constrained by what is practicably measurable within a society where an operational initiative, i.e. project or technology (from an industry perspective), will typically occur. The availability of information is likely to differ be-

tween developed and developing countries. Furthermore, the projection of the social interventions of a project or technology may be problematic or at least differ from case to case. Separate studies may be required for some of the social sustainability criteria, e.g. stakeholder participation, even at project-specific level, which may be problematic.

3 Case Studies to Demonstrate and Test the SII Calculation Method

The SII calculation method was applied to three case studies to determine the current feasibility thereof in terms of data availability. In the third case study, environmental Resource Impact Indicators were also calculated using the RII method [15]. All case studies are set in South Africa and project information was obtained from Environmental Impact Assessment (EIA) studies as well as interviews with members of the respective project teams. Due to the hindsight application of the SII method no additional data could be collected from a project perspective. Social footprint information was obtained from:

- Statistics South Africa [18];
- South African Department of Transport [19];
- South African Council for Scientific and Industrial Research (CSIR) [20];
- South African Department of Health [21];
- South African Department of Labour [22];
- NOSA International [23]; and
- Municipal Demarcation Board South Africa [24] and individual municipalities, e.g. some municipalities have undertaken Strategic Environmental Assessments (SEAs) in certain regions of South Africa.

In the case studies, mid-point categories were evaluated in respect of whether both project and social footprint information are available, and if the respective information is comparable. It is noted that whereas LCA normally considers a product's life cycle, these case studies focus on the asset, or technology, life cycle (as described in section 1.2) with the functional unit being one operational year of the asset. However, since the asset life cycle and the associate product life cycle interact through the asset's operational phase [10], the indicators could be translated to a typical product-manufactured functional unit.

3.1 Construction of an open cast mine

3.1.1 Background

In 1996 a petrochemical company in South Africa announced its intention to develop an Open Cast Strip Mine on the banks of the Vaal River between the Gauteng and Free State Provinces. The project was motivated on the basis that the reserves of the company's main mine in the area had reached the end of its economic life and that this posed a threat to the future of a large chemical manufacturer in a nearby town, which was supplied by the mine from 1952. Ultimately, a threat to the existence of the chemical manufacturer is a direct threat to the existence of the town and in a sense the province since the manufacturer contributes 12% to the geographical economy of the region. The project was met with a lot of resistance from the public, especially owners of riverside properties. The project was stopped after a non-governmental organisation took the company to court and won a legal battle, which changed the mining legislation of South Africa.

3.1.2 Available project and social footprint information

Tables 6 and **7** summarise the available project information and social footprint information that have been obtained from the Environmental Management Programme Report [25] and the specialist study on the macro social economic impacts [26].

3.1.3 SIIs for the project

The information presented in Tables 6 and 7 highlights the mismatch between available project and social footprint information. SIIs were calculated as far as possible where both appropriate project and social footprint information was available for midpoint categories (**Table 8**) using Eq. 1.

The project will have an overall positive social impact, although job creation could not outweigh the negative impact on the comfort level on the neighbourhoods in a close vicinity to the plant. The overall positive impact is mainly due to the large contribution the project will make to the Gross Geographic Product (GGP) of a relative small area, which relies strongly on mining.

Table 6: Available project social intervention information for the proposed mine

	Construction	Operation
Employment Opportunities created	450 people [24:138]	300[a] employment opportunities over a 20 year life span [24:121]
Employment Opportunities destroyed	20 employment opportunities on farms[a] [24: 267]	
Indirect Employment Opportunities	Multiplier effect of 2.8: 1260	Multiplier effect of 2.8: 840[a]
Contribution to GDP (added or lost)	R52 million per annum[a] (in 1999/2000) [25:32]	
Reduction in property values	9-19% (year 1–10) [24: 258]	2–6% (after year 10 till mine closure) [24:258]
Increases in Ambient Noise levels (dBa) on Average	<2 [24: 195]	< 2[a] [24: 238–239]
Dust (mg/day/m^2)	Between <50–250 [24: 187]	<100[a] [24: 231]

a These values are used as quantifiable social interventions (Q_x) in the SII calculation procedure. The South African Rand is equal to approximately 0.12 Euros (as at the end of October 2005).

Table 7: Available social footprint information for the region of the proposed mine

Labour Force: Potentially Economically Active [25: 55]			
Total	**Employed**	**Unemployed**	**Not-economically active**
736,721	308,826[a]	149,335[a]	278,560
100%	41.9%	20.3%	37.8%
Estimated ambient noise level (dBA) [24: 97]			
Time of day	**Typical weekday**	**Typical weekend**	
Morning	50.9	49.2	
Midday	46.9	48.0	
Evening	41.4	46.9	
Night	34.7	42.3	
Over 24 hours	44.6[b]	46.8[b]	
Sasolburg GDP (1991) due to kind of activity [25: 59]			
Mining & Quarrying	R 259 677 000 per annum[c]		
Dust Pattern [25]			
March–July	Low		
August–December	Higher		
January–February	Lower		
Dust Figures [25]			
September	Moderate	251–500 mg/day/m^2	
October (2 x sites)	Heavy	501–1200 mg/day/m^2	
November (1 site)	Heavy	501–1200 mg/day/m^2	

[a] The sum of these values are the target state for the region. The current state refers to only the value 308,826.
[b] The average of these two values are used as the target state for the region. The current state is assumed equal to the target state.
[c] Value used for target and current state for the region. The South African Rand is equal to approximately 0.12 Euros (as at the end of October 2005)

3.2 Operation of a chemical facility

3.2.1 Background

The chemical facility is located on a 6,798 ha industrial site in South Africa. The construction of the site started in the early 1970s and was finished in 1980. It employs approximately 7000 permanent employees. The facility contributes 13% to the economy of the geographic region.

3.2.2 Available operation and social footprint information

The following sources of information were used to calculate SIIs:

- The company's Sustainable Development Report;
- A Strategic Environmental Assessment of the area;
- South African Census Information; and
- South Africa's Compensation Fund Statistics.

References of these sources are withheld to protect the company's identity. **Table 9** summarises the available plant information and social footprint information that were obtained.

3.2.3 SIIs for the operation

Table 10 shows the calculated SIIs using Eq. 1.

Table 10 shows that the operation of the plant has in total a negative social impact. The positive contribution to GDP

Table 8: Calculated Social Impact Indicators for the proposed open cast mine from the available case study information

Area of Protection	Intervent.	Midpoint Category	Intervent. Value	Normalisation Value (T_S^{-1})	Significance Value (C_S/T_S)	Midpoint Indicator Value	SII Value
Internal Human Resources	Employment Creation	Permanent Positions	300 in total	2.183×10^{-06}	0.674	4.41×10^{-04}	**4.4×10^{-04}**
External Population	Permanent Positions	Local Employment	2195200 hrs[a]	1.11×10^{-09}	0.674	1.65×10^{-03}	**-7.5×10^{-02}**
	Noise & Dust[b] Generated[1]	Comfort Level	2 dBA 100 mg/d/m^2	2.19×10^{-02} 1.09×10^{-03}	1 1	-4.38×10^{-02} -1.09×10^{-01}	
Macro Social Performance	Nature of Sales[2]	External Value of Purchases	R 52 mil.	3.85×10^{-03}	1	2.0×10^{-01}	**2.0×10^{-01}**
Stakeholder Participation	No information available						
Final Social Impact Value							**1.25×10^{-01}**

[a] Total of 1140 permanent positions at 40 hours per week assumed for 49 weeks (three weeks vacation, etc.).
[b] A target (and current) state is taken as the weighted average for the region, i.e. 916 mg/day/m^2.
[1] Since no characterisation factors for noise to dust or dust to noise is available, the midpoint. category was calculated as a weighted average with equal weights to each constituent.
[2] The units of equivalence have been changed to contribution to GDP due to the information available.

Table 9: Available operational and social footprint information for the region of the chemical facility

Intervention[a]	Plant Information[b]	Social Footprint Information
Employees	± 7,000	Target: To have everyone employed excluding people who prefer to be not economically active. Govan Mbeki Municipality: Employed: 60,681 Unemployed: 40,189; Total Labour Force: 100,870.
Indirect Employment Creation	± 21,000 (applying the rule of 3 used in SIAs)	Employable Community Work hours – assuming all full-time employees – 40 hours – 49 weeks (3 weeks leave).
Total Injuries	541	13 019 (target and current state assumed equal).
Disabling Injury Rate (no/200,000 hours)	0.59	Not available
Health & Safety Incidents (Spillages)	70	Not available
Atmospheric Emissions:		Not available
SO_2	197 kilo ton	Not available
NO_x	138.8 kilo ton	Not available
VOC	394 kilo ton	Not available
H_2S	90 kilo ton (Permit: 101)	Not available
CO_2	44,109.2 kilo ton	Not available
Atmospheric Emissions (concentration information from SEA)		
NO_x	1 Hour Maximum NO_2 concentration Average of 5 receptor points: 539. 4μg/m^3	Acceptable Target (WHO guideline): 200 μg/m^3 (1-hour NO_x average) Current State: 1 Hour Maximum NO_2 concentration based on maximum predicted concentration: 801 μg/m^3
SO_2	24 Hour Maximum SO_2 Concentration based on average of 5 receptor points: 127.4 μg/m^3	Acceptable Target (WHO guideline): 125 μg/m^3 Current State: 24 Hour Maximum SO_2 Concentration based on based on maximum predicted concentration: 152 μg/m^3
Water Usage – River Water	89,963 m^3	Target: (1:200 year firm yield) 150 million m^3 per annum Current (predicted 1998/2000 average) 183.6 million m^3 per annum
Financial Turnover[c]	R 7835 million	R 49,707 million
Transportation Incidents	12	Not available
Complaints	36	Not available

[a] Only those quantifiable social interventions for which plant and social footprint information is available, are used in the SII calculation procedure.
[b] All plant information has been obtained from the Sustainable Development Report where the average of data available has been used unless otherwise stated.
[c] The South African Rand is equal to approximately 0.12 Euros (as at the end of October 2005).

Table 10: Calculated Social Impact Indicators for the chemical facility from the available case study information

Area of Protection	Intervent.	Midpoint Category	Intervent. Value	Normalisation Value (T_S^{-1})	Significance Value (C_S/T_S)	Midpoint Indicator Value	SII Value
Internal Human Resources	Employment Creation	Permanent Positions	7,000	9.91×10^{-06}	0.602	4.17×10^{-02}	**1.9×10^{-04}**
	Health & Safety Incidents	Possible Health and Safety Incidents	541	7.68×10^{-05}	1	-4.16×10^{-02}	
External Population	Permanent Positions	Local Employment	41,167,000 hrs	5.06×10^{-09}	0.602	0.125	**–1.85**
	Atmospheric Emissions (SO_2)	Comfort Level	127.4 μg/m^3	0.008	1.216	–1.239	
	Water Usage	Availability of water services	89.963 m^3	0.007	1.224	–0.734	
Macro Social Performance	Nature of Sales	External Value of Purchases	R 7835 mil.	2.01×10^{-05}	1	0.158	**0.158**
Stakeholder Participation	No information available						
Final Social Impact Value							**-1.69×10^{-01}**

and employment cannot outweigh the negative impacts on comfort level, people (in the form of health and safety accidents), and the water usage. The biggest social impact is the impact on comfort level due to atmospheric emissions, i.e. secondary environmental impacts.

3.3 Decommissioning of a fibre manufacturing plant

3.3.1 Background

In the early 1990s a second-hand acrylic fibre plant from a manufacturing facility in France was dismantled and relocated in the KwaZulu Province of South Africa. However, the decreasing acrylic fibre market in South Africa, combined with a lack of import protection, led to the decision to decommission the plant in March 2002. The plant manufactured its last products in May 2002, which were sold in August 2002. The plant was dismantled and the site rehabilitated by March 2003.

3.3.2 Available project and social footprint information

Using the company's sustainable development report, the Strategic Environmental Assessment (SEA) of the region, as well as the sustainable development indicator data of the municipal area in which the plant operated, the SII calculation procedure was applied to calculate the social impacts. In addition, environmental RIIs were calculated using standard RII values, which were calculated for selected process parameters [27]. **Table 11** shows the available project and social footprint information.

3.3.3 Environmental and social impact indicators

Tables 12 and **13** show the calculated Social and Environmental Impact Indicators.

The values in Tables 12 and 13 show that although a similar methodology was followed to calculate SIIs compared to RIIs, the indicator outcomes are vastly different. This highlights that the interpretation of indicators remains challenging. Assessing the overall sustainability performance of a project or technology by allowing trade-offs between the contributions and damages should be seriously considered before it is applied. Ultimately, the trade-offs between the different dimensions would be the responsibility of the specific decision-makers, and therefore reflect the preferences of the decision-makers.

3.4 Conclusions from the case studies

As stated before it is not easy to generalise from case study research. However, the case studies showed that it is not possible to calculate all social midpoint category indicators,

Table 11: Available project and social footprint information for the region of the fibres plant

Intervention[a]	Project Information	Social Footprint Information
Nature of Jobs	250 employment opportunities lost (5% relocated = 12)	eThekwini unemployment: 591,024 eThekwini employment: 782,933 Target: To have everyone employed excluding people who prefer to be not economically active.
Indirect Employment Destruction	± 750 (applying the rule of 3 used in SIAs)	Employable Community Work hours – assuming all full-time employees – 40 hours – 49 weeks (3 weeks leave).
Work-hours lost due to injuries	475.25 hours	
Disabling Injuries	6.5	Although social footprint information is available the definition of disabling injuries is not given and therefore information is not comparable.
Disabling Injury Rate (no per 200 000 hours)	2.375	Not available
Health & Safety Incidents (Spillages)	0.75 per annum	Not available
Atmospheric Emissions:		**eThekwini Emissions**
SO_2	0.488 kilo ton per annum	54.50 kilo ton per annum
NO_x	0.111 kilo ton per annum	54.50 kilo ton per annum
VOC	0.005 kilo ton per annum	No information available
Water Usage	1,429,200 kilo litre per annum	eThekwini – with water loss: 168,090 ML – without water loss: 280,149 ML
Energy Usage	48.384 GWh per annum	eThekwini: 9098 GWh per annum
Solid Waste:	5.25×10^3 m^3 per annum	Not available
General/Domestic	2.575×10^3 m^3 per annum 1,545 tons per annum[b]	Durban South Basin: 45,000 ton per annum
Non-Hazardous Industrial	2.675×10^3 m^3 per annum	Not available
Nature of Sales[c]	Annual turnover of R 500 million	GDP of Kwa Zulu Natal: R 113,047 million
Stakeholder Complaints	0.5 per annum	

[a] Only those quantifiable social interventions for which plant and social footprint information is available, are used in the SII calculation procedure.
[b] The South African Department of Water Affairs and Forestry's minimum requirements for waste density was used for the conversion.
[c] The South African Rand is equal to approximately 0.12 Euros (as at the end of October 2005).

Table 12: Calculated Social Impact Indicators for the decommissioning of the fibres plant from the available case study information

Area of Protection	Intervent.	Midpoint Category	Intervent. Value	Normalisation Value (T_S^{-1})	Significance Value (C_S/T_S)	Midpoint Indicator Value	SII Value
Internal Human Resources	Employment Creation	Permanent Positions	262	7.28×10^{-07}	0.570	-1.09×10^{-04}	**-1.1×10^{-04}**
External Population	Permanent Positions	Local Employment	1,983,520 hrs	3.71×10^{-10}	0.570	-4.20×10^{-04}	**5.47×10^{-04}**
	Energy Usage	Availability of energy services	48.384 GWh	1.1×10^{-04}	1	5.32×10^{-03}	
	Water Usage	Availability of water services	1,429,200 kl	3.57×10^{-09}	1	5.10×10^{-03}	
	Waste Generated[a]	Availability of waste services	1 545 t	2.22×10^{-05}	1	3.43×10^{-02}	
	Atmospheric Emissions (SO_2 & NO_x)[b]	Comfort Level	0.565 kt SO_2 eq.	2.84×10^{-02}	a	1.04×10^{-02}	
Macro Social Performance	Nature of Sales[c]	External Value of Purchases	R 500 mil.	7.98×10^{-06}	1	-3.99×10^{-03}	**-4.0×10^{-03}**
Stakeholder Participation	No information available						
Final Social Impact Value							**5.06×10^{-02}**

[a] Based on information available the units of equivalence have been changed to domestic waste generated in tons.
[b] Comfort level is measured quantitatively in kilo tons SO_2 per annum using CML characterisation factors.
[c] The units of equivalence have been changed to contribution to GDP due to the information available. The South African Rand is equal to approximately 0.12 Euros (as at the end of October 2005).

Table 13: Calculated environmental Resource Impact Indicators for the decommissioning of the fibres plant from the available case study information

Process Parameter (annual quantities)		Water	Air	Land	Mined
Waste	1,545,000 kg	7.29×10^{-02}	2.33×10^{-06}	4.22×10^{-02}	0
Electricity used	174,182,400 MJ	7.88×10^{5}	1.79×10^{4}	1.68×10^{2}	8.81×10^{1}
Coal Used	46,368,000 kg	0	0	0	1.67×10^{2}
Steam used	354,960,000 kg	2.60×10^{4}	2.51×10^{2}	4.41	1.52×10^{2}
Water used	1,429,200,000 kg	7.00×10^{4}	0	0	0
Resource Impact Indicator		**$8.84 \times 10^{+05}$**	**$1.81 \times 10^{+04}$**	**$1.72 \times 10^{+02}$**	**$4.07 \times 10^{+02}$**

either because of a lack of project information, or because of a lack of social footprint information. In addition, the units of equivalence cannot be fixed since they depend on the available information. This complicates indicator comparisons between various projects. The limitation of available social footprint information results in the fact that only some midpoint category indicators are possible, i.e. permanent positions, water usage, energy usage, nature of sales, and comfort level, which leads to an impaired social picture. In addition, the midpoint category indicators for water usage, energy usage and comfort level are much higher than permanent positions, thus resulting in a net negative social impact for any proposed development, which may not be a representation of the true social influence of the project or technology.

4 Conclusions and Recommendations

A case study independent analysis of available social footprint information in South Africa confirmed the main finding of this paper that social footprint information is not available for all midpoint categories [28]. It is regarded as an international problem that current available statistics are incapable of providing an integrated view of various dimensions of sustainable development [29]. The research therefore concludes that a quantitative social impact assessment method cannot be applied for project and technology life cycle management purposes in industry at present. It is emphasised that these conclusions were reached from a process LCA perspective, which is industry sector-wide. Research with a product LCA focus may lead to different outcomes. Although a comprehensive top-down approach was followed, a bottom-up approach may be more appropriate for product LCAs [30], as the selection of suitable criteria would be constrained to the specific scope of a LCA study.

4.1 Further steps to quantify social impact indicators

It is proposed that social sustainability should be incorporated into project and technology life cycle management by means of guidelines and checklists. Similar to the environmental dimension, it is envisaged that such checklists and guidelines would improve the availability of quantitative data in time, and would therefore make the SII procedure more practical in the future. Although such guidelines and checklists have been developed from a theoretical perspective [28], practical guidelines and checklists from a project or technology life cycle management perspective are yet to be dem-

onstrated. Further cases are subsequently required for demonstration and analysis purposes.

While the guidelines and checklists may lead to a paradigm shift in industry towards obtaining and evaluating social impact-related information, it is also suggested that a less-comprehensive list of social criteria is used as a starting point to develop social LCA-specific methodologies, possibly using those midpoint category indicators that were quantifiable in the case studies of this research, i.e. permanent positions, water usage, energy usage, nature of sales, and comfort level, or other midpoint categories that are currently proposed [30]. However, social issues are highly influenced by cultural perceptions, and it would be best to undertake such a task at national level. National indicator sets can then be compared and combined on an international level.

In addition, it is suggested that the development of data quality standards are required for social criteria, similar to the efforts of SETAC and ISO for the environmental criteria used in LCA today. Such standards would greatly improve the transparency of calculated indicators.

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Appendix

The causal relationship maps are broken down into 7 diagrams. Four diagrams are used to show the causal relationship diagram for the External Population area of protection, while the causal relationships for the other areas of protection are shown in separate diagrams.

Internal Human Resources (IHR)

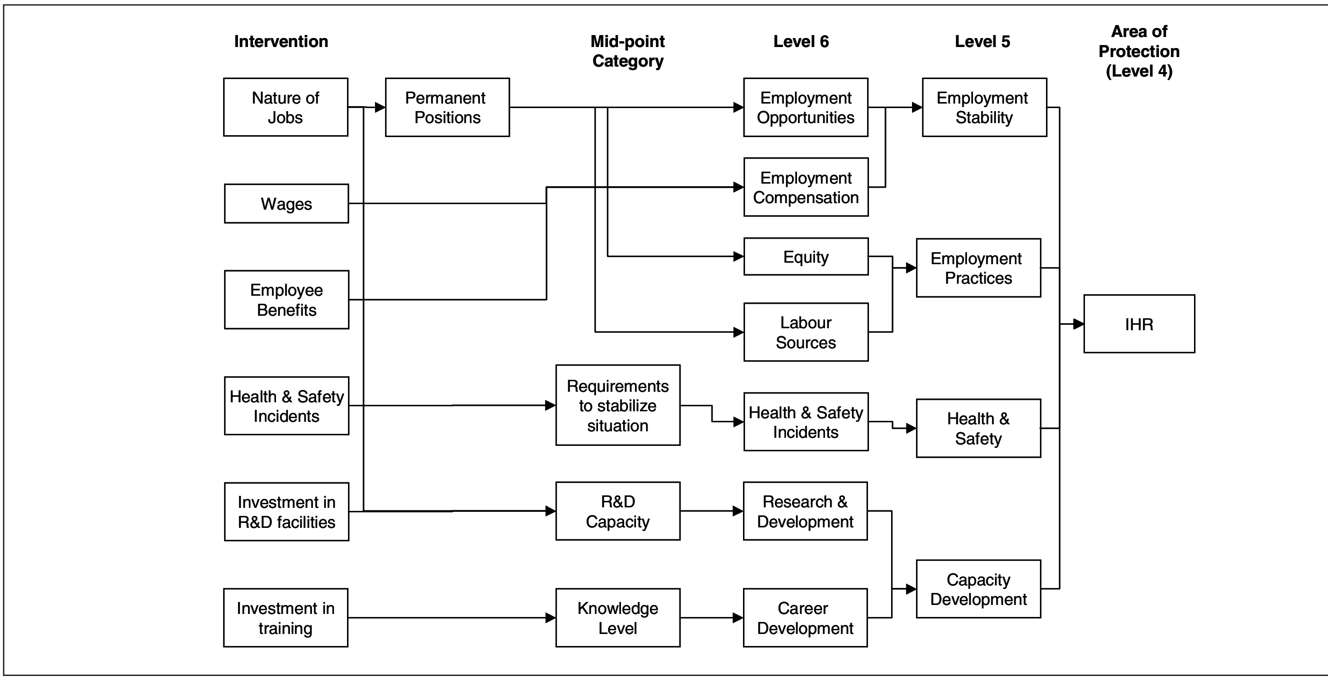

Fig. 2: Casual relationship map for the main social criterion Internal Human Resources [16]

External Population (EP)

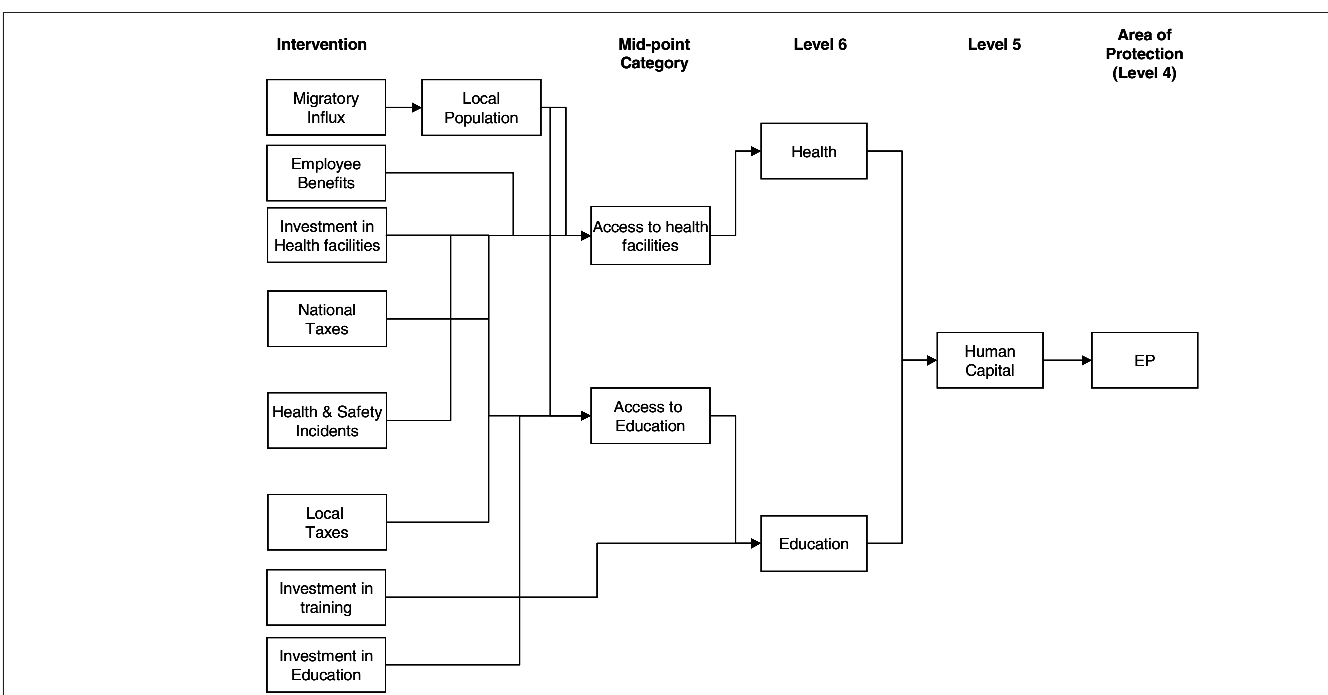

Fig. 3: Casual relationship map for the main social criterion External Population: Human Capital [16]

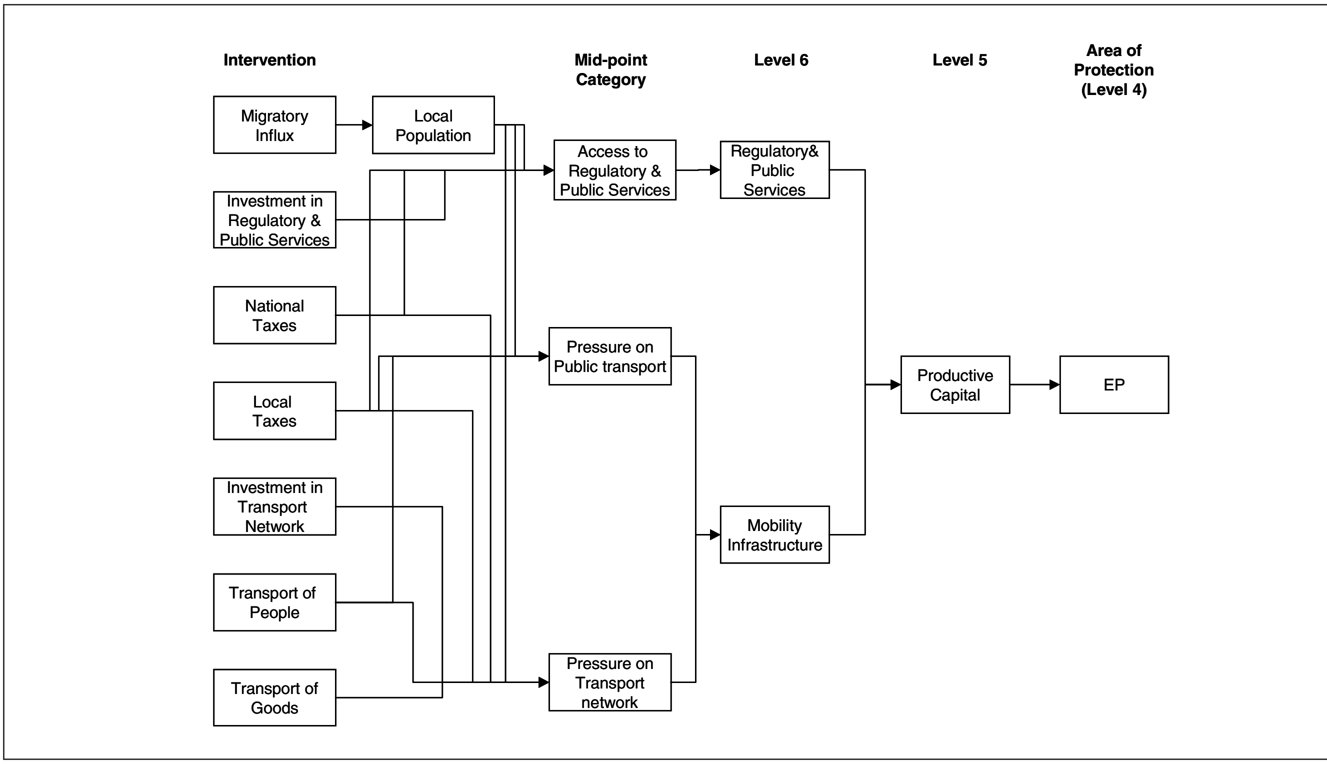

Fig. 4: Casual relationship map for the main social criterion External Population: Productive Capital (1) [16]

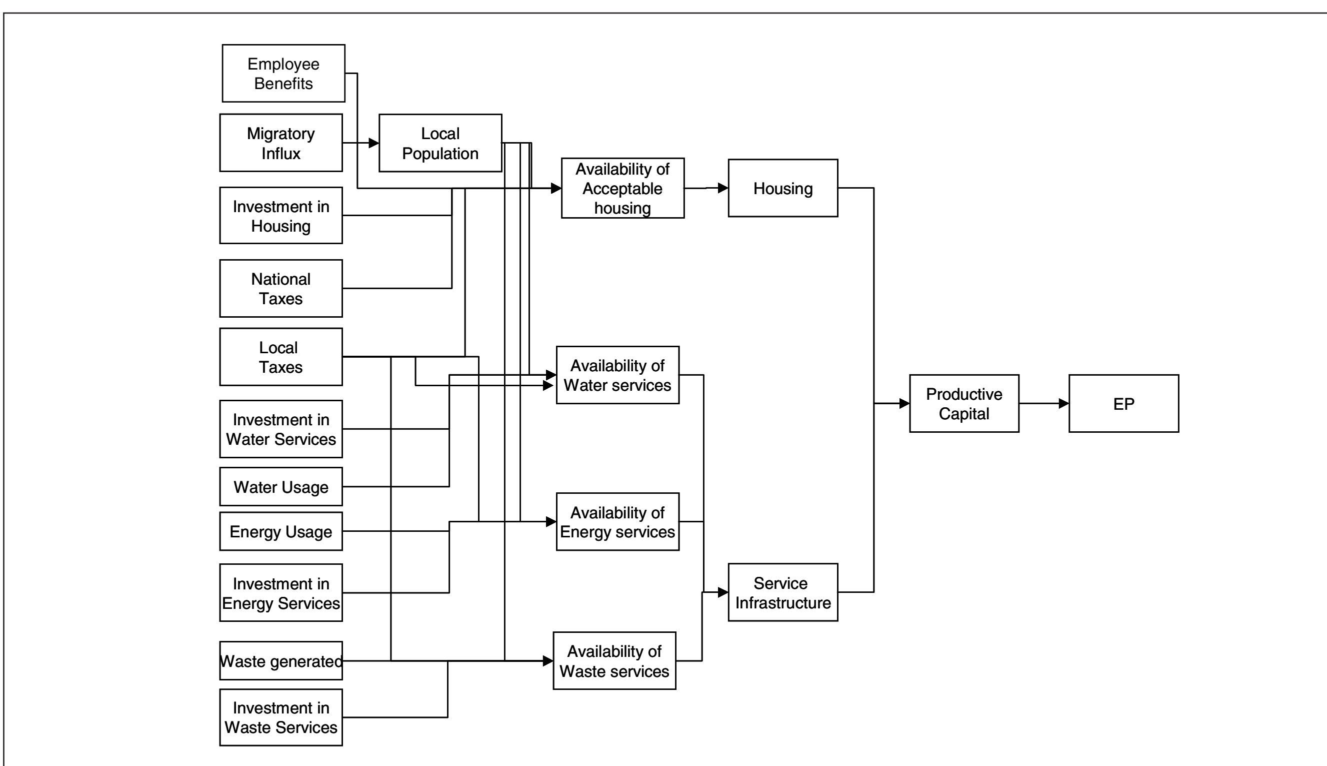

Fig. 5: Casual relationship map for the main social criterion External Population: Productive Capital (2) [16]

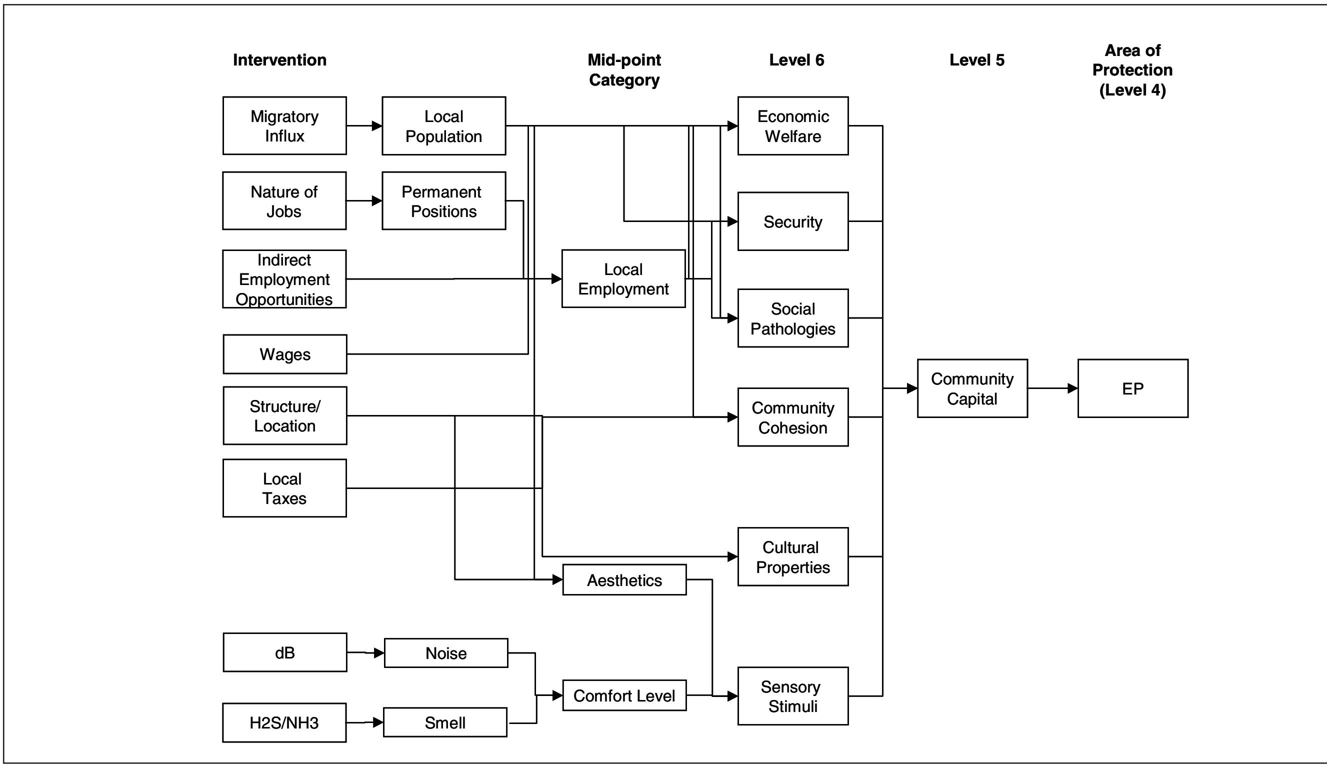

Fig. 6: Casual relationship map for the main social criterion External Population: Community Capital [16]

Macro Social Performance (MSP)

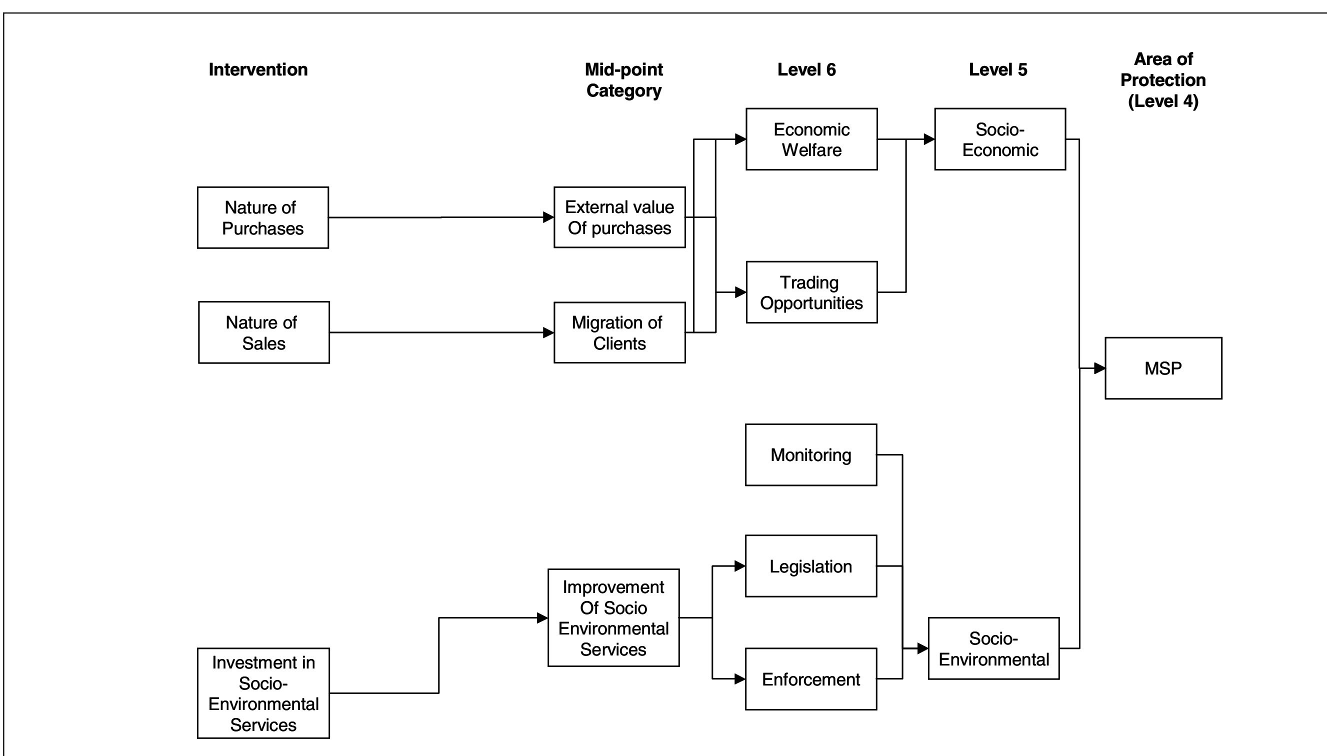

Fig. 7: Casual relationship map for the main social criterion Macro Social Performance [16]

Stakeholder Participation (SP)

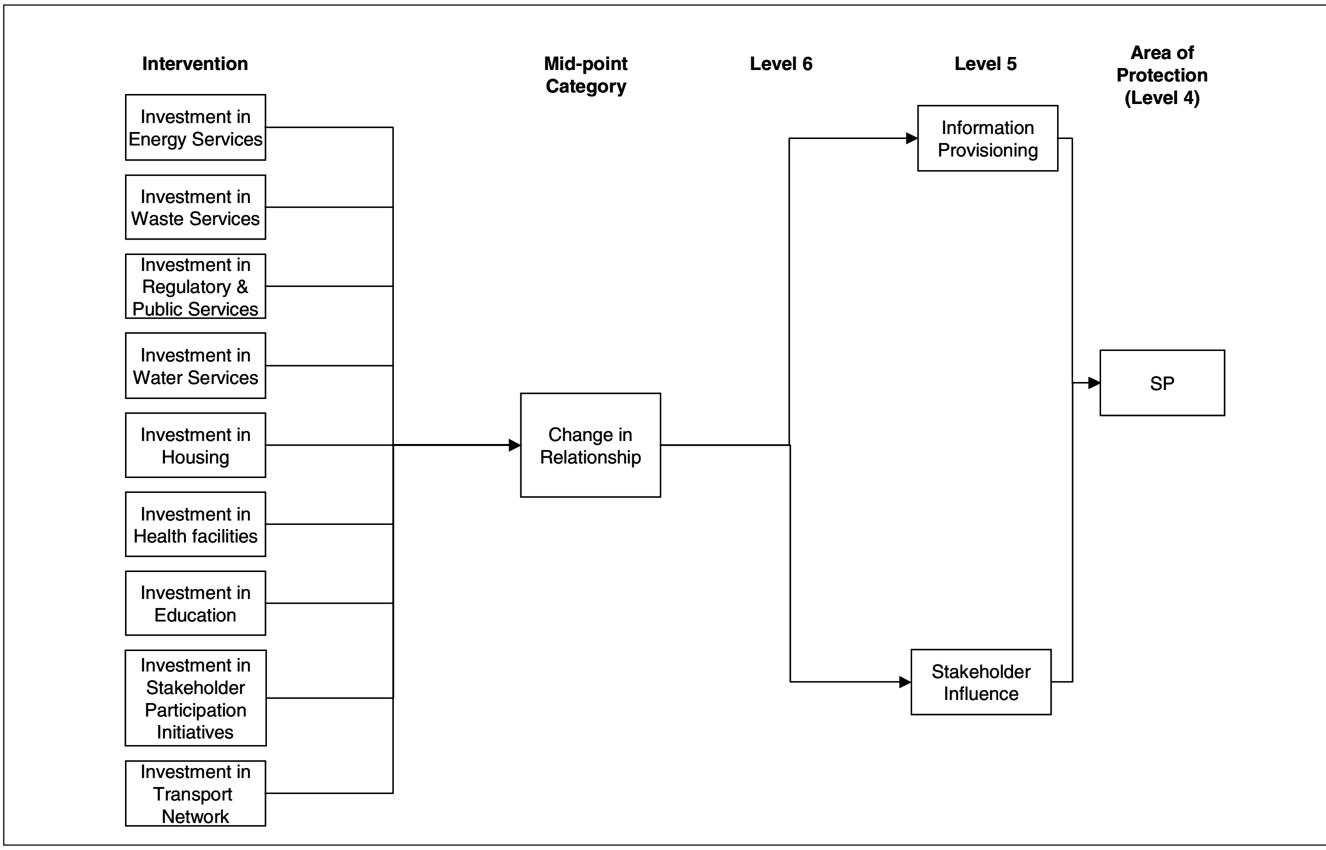

Fig. 8: Casual relationship map for the main social criterion Stakeholder Participation [16]